FIG 1

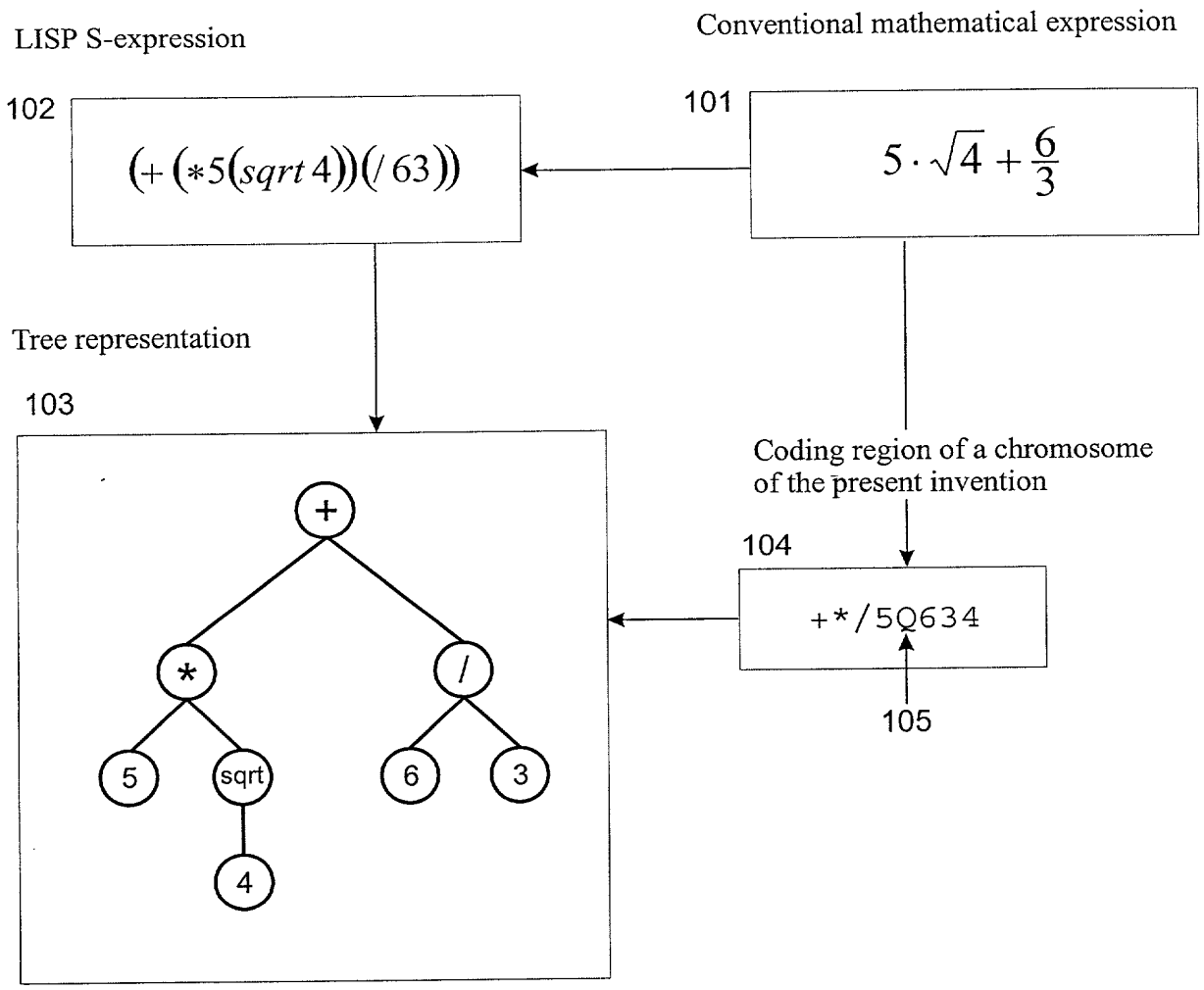

LISP S-expression
Conventional mathematical expression
102
101
(+ (*5(sqrt 4))(/ 63))
$5 \cdot \sqrt{4} + \frac{6}{3}$
Tree representation
103
Coding region of a chromosome of the present invention
104
+*/5Q634
105
+
*
/
5
sqrt
6
3
4

FIG 2

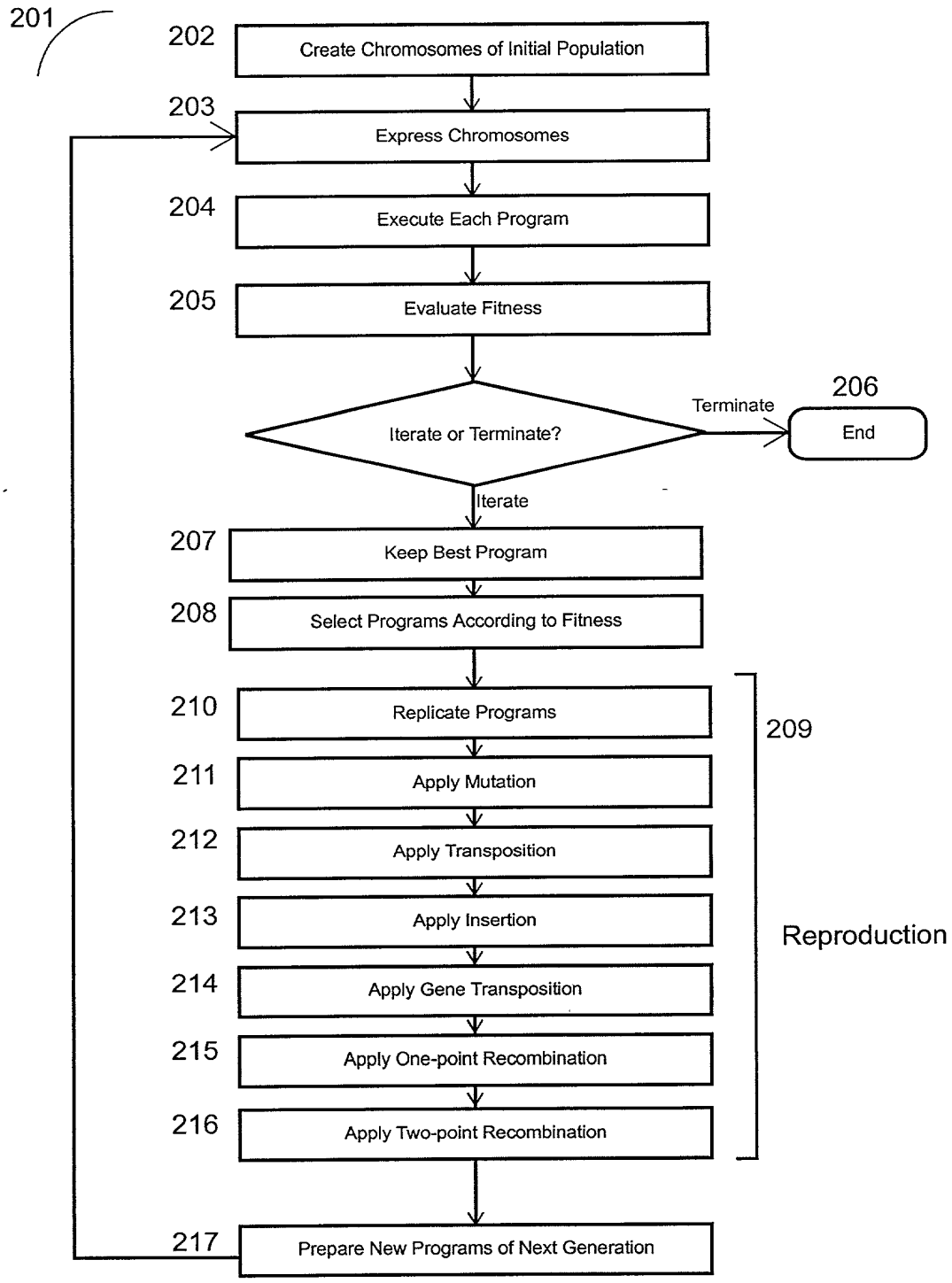

201
202
Create Chromosomes of Initial Population
203
Express Chromosomes
204
Execute Each Program
205
Evaluate Fitness
Iterate or Terminate?
Terminate
206
End
Iterate
207
Keep Best Program
208
Select Programs According to Fitness
210
Replicate Programs
211
Apply Mutation
212
Apply Transposition
213
Apply Insertion
214
Apply Gene Transposition
215
Apply One-point Recombination
216
Apply Two-point Recombination
209
Reproduction
217
Prepare New Programs of Next Generation

FIG 3

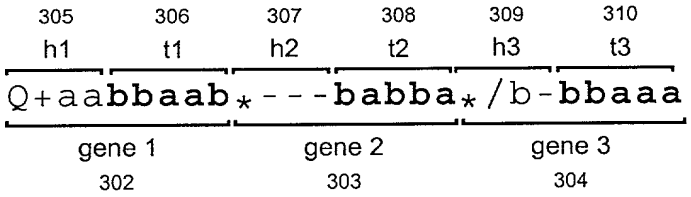


FIG 4

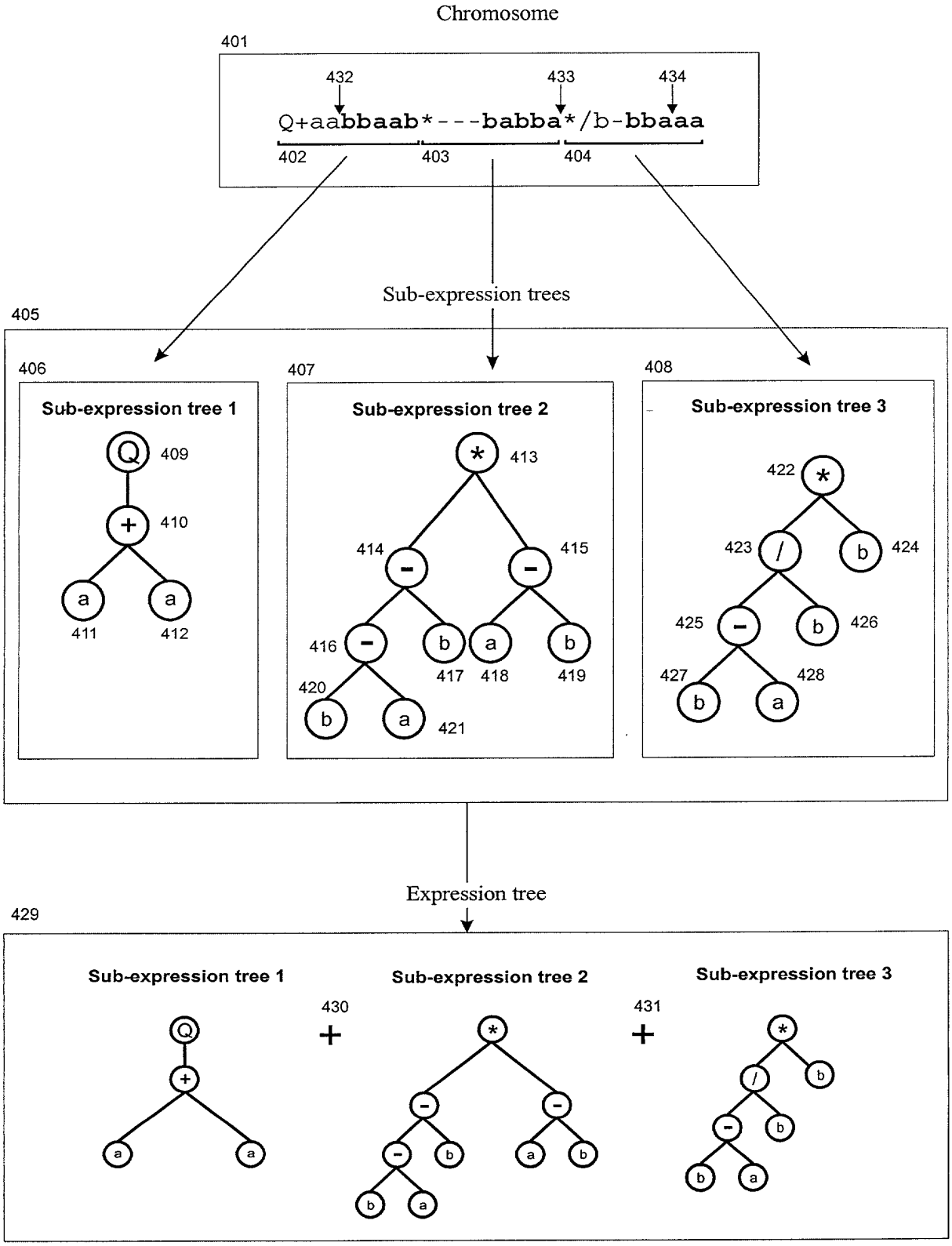

Chromosome
401
432
433
434
Q+aabbaab*---babba*/b-bbaaa
402
403
404
Sub-expression trees
405
406
Sub-expression tree 1
Q
409
+
410
a
a
411
412
407
Sub-expression tree 2
*
413
414
-
415
-
416
-
b
a
b
417
418
419
420
b
a
421
408
Sub-expression tree 3
422
*
423
/
b
424
425
-
b
426
427
428
b
a
Expression tree
429
Sub-expression tree 1
Sub-expression tree 2
Sub-expression tree 3
430
+
431
+

FIG 5

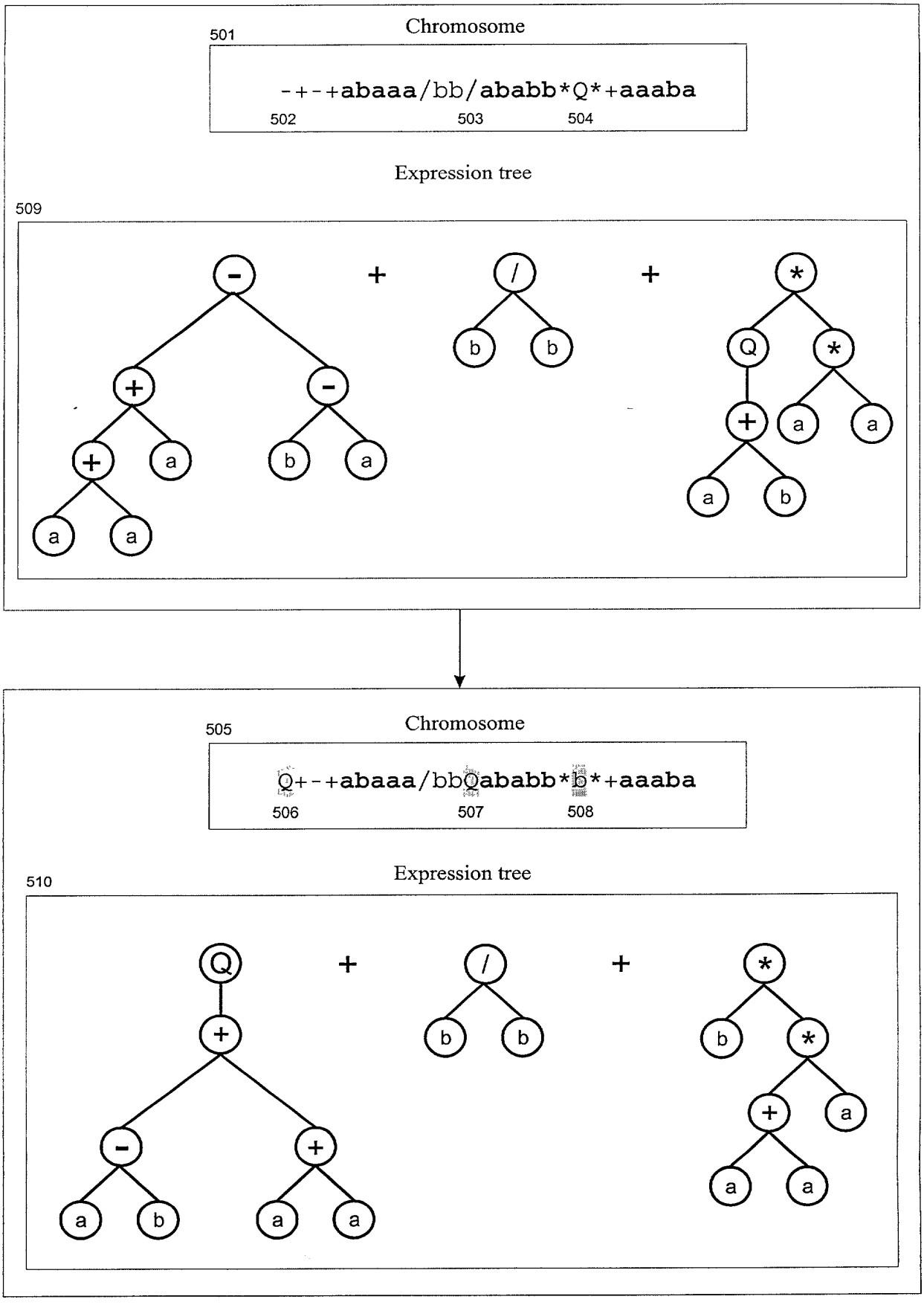

Chromosome
501
-+-+abaaa/bb/ababb*Q*+aaaba
502
503
504
Expression tree
509
Chromosome
505
Q+-+abaaa/bbQababb*b*+aaaba
506
507
508
Expression tree
510

FIG 6

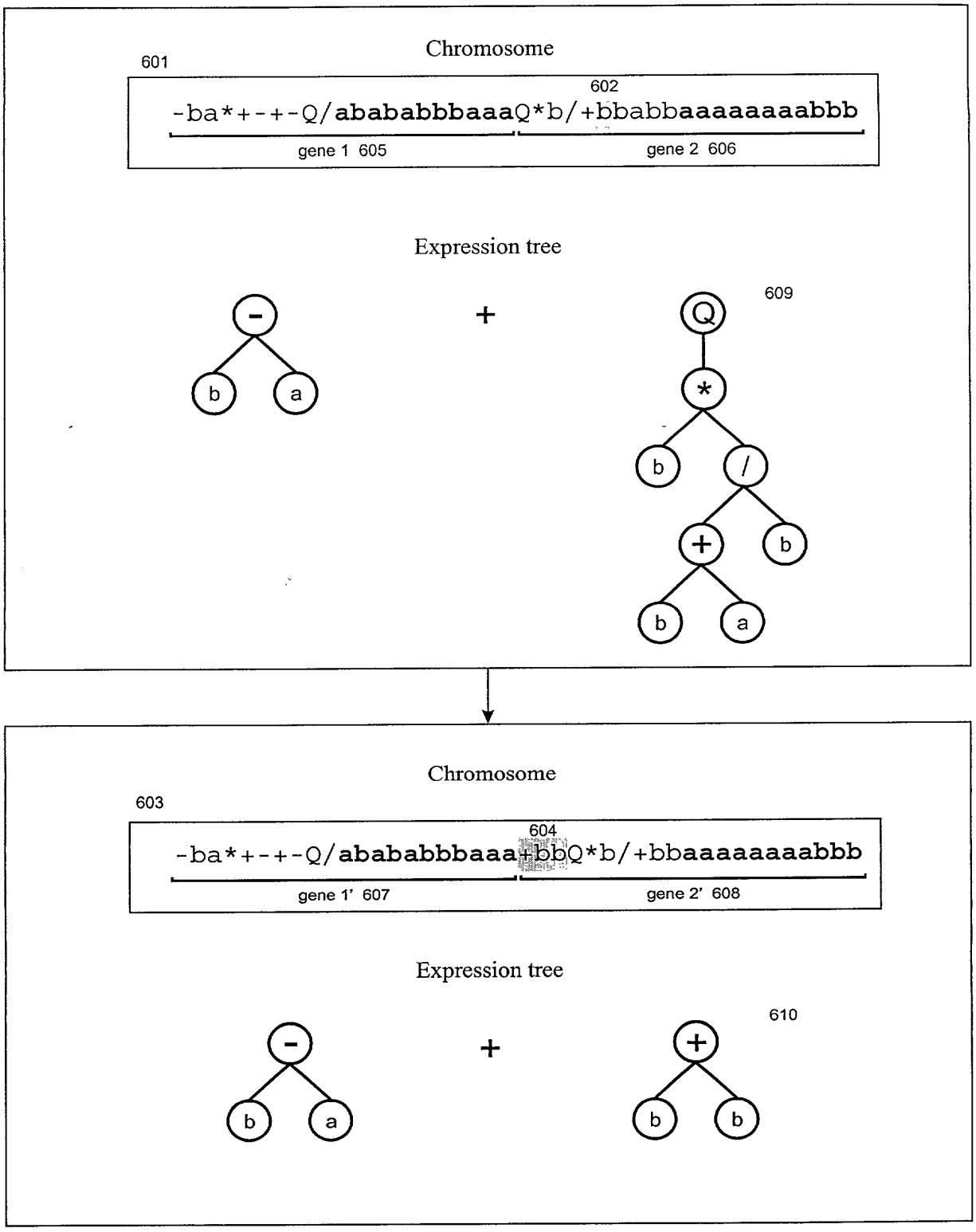

Chromosome
601
602
-ba*+-+-Q/abababbbaaaQ*b/+bbabbaaaaaaaaabbb
gene 1 605
gene 2 606
Expression tree
609
Chromosome
603
604
-ba*+-+-Q/abababbbaaa+bbQ*b/+bbaaaaaaaabbb
gene 1' 607
gene 2' 608
Expression tree
610

FIG 7

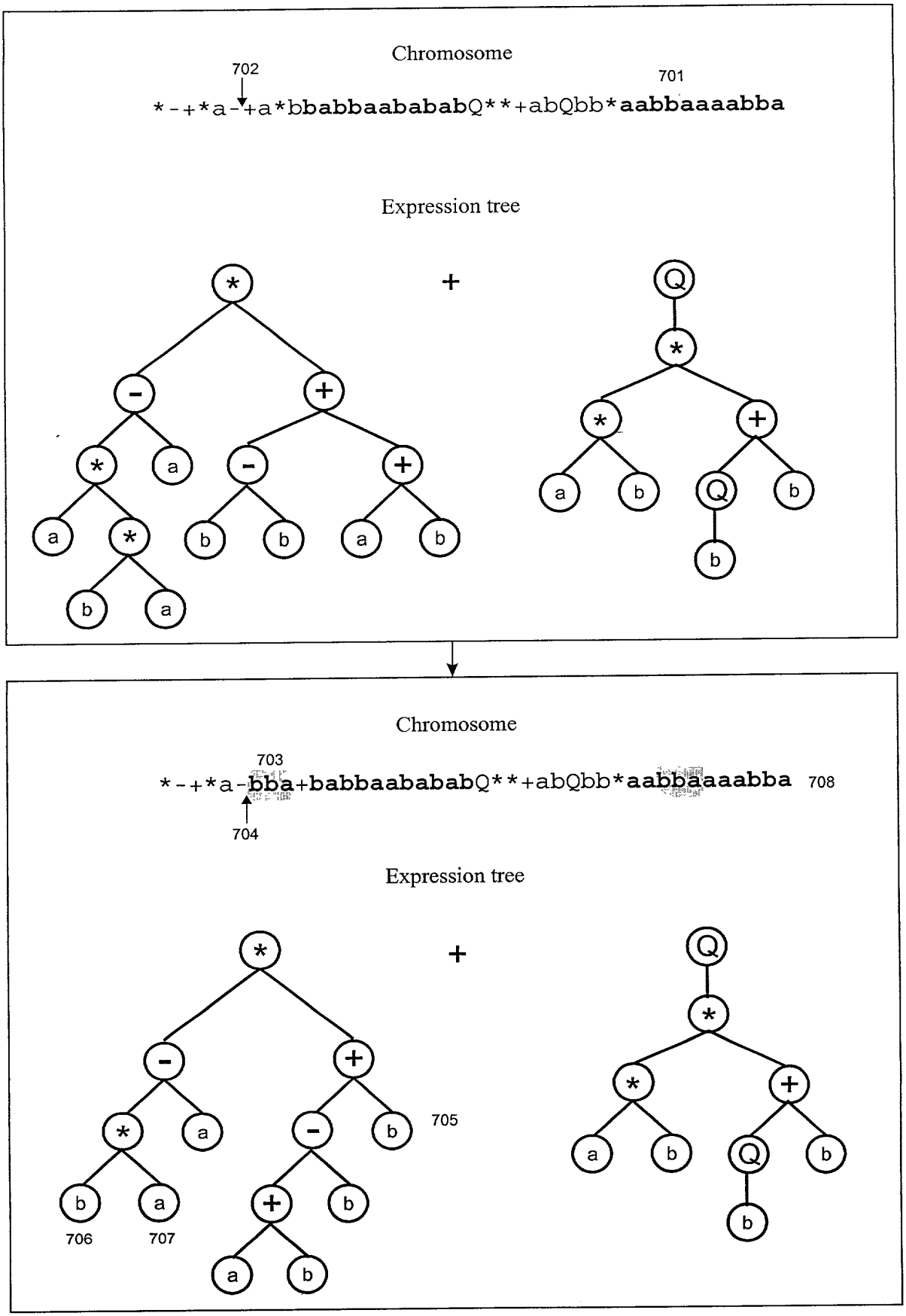

Chromosome
702
701
*-+*a-+a*bbabbaababQ**+abQbb*aabbaaaabba
Expression tree
+
Chromosome
703
*-+*a-bba+babbaababQ**+abQbb*aabbaaaabba
708
704
Expression tree
+
705
706
707

FIG 8

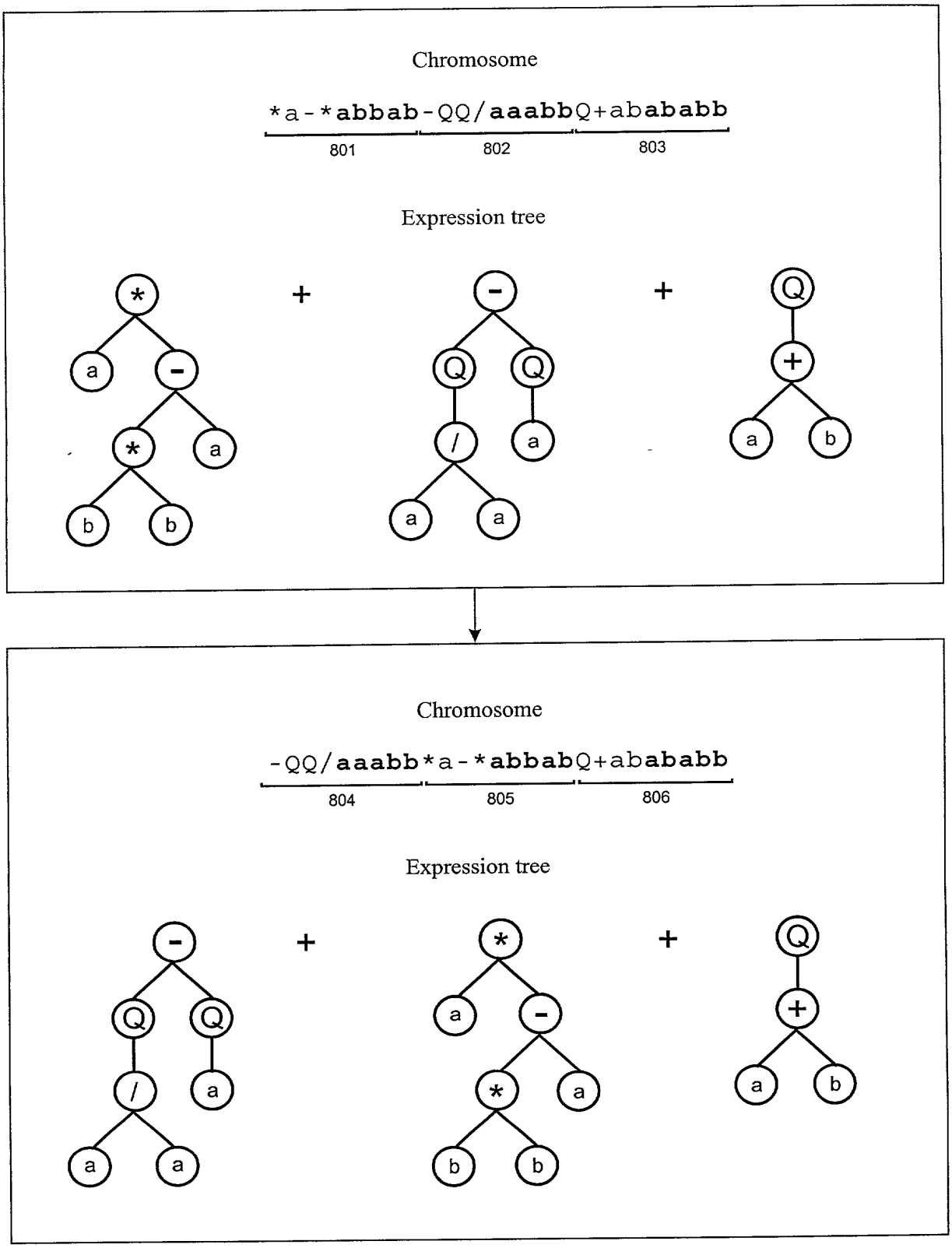

Chromosome
*a-*abbab-QQ/aaabbQ+ababbb
801
802
803
Expression tree
Chromosome
-QQ/aaabb*a-*abbabQ+ababbb
804
805
806
Expression tree

FIG 9

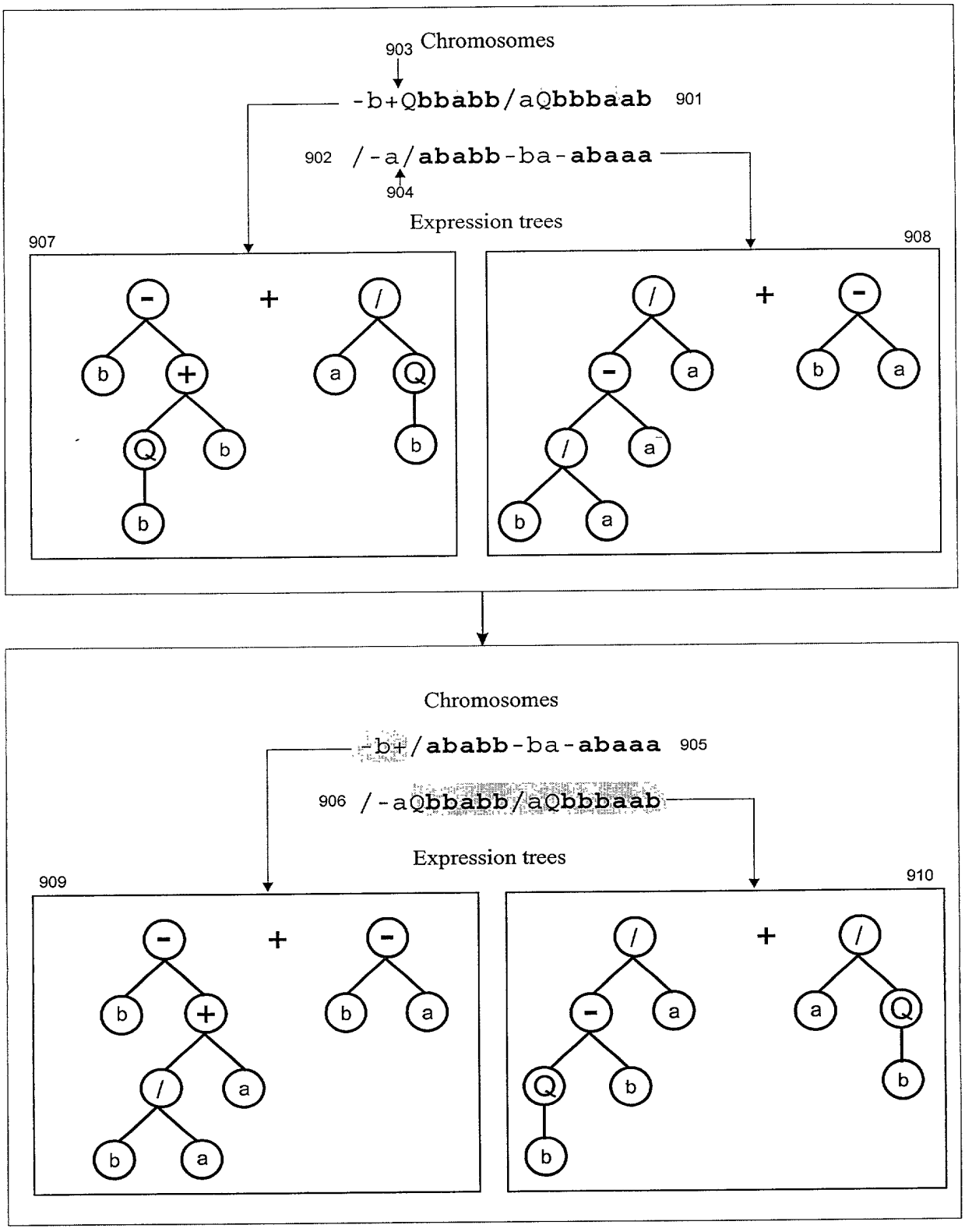

903 Chromosomes
-b+Qbbabb/aQbbbaab 901
902 /-a/ababb-ba-abaaa
904
Expression trees
907
908
Chromosomes
-b+/ababb-ba-abaaa 905
906 /-aQbbabb/aQbbbaab
Expression trees
909
910

FIG 10A

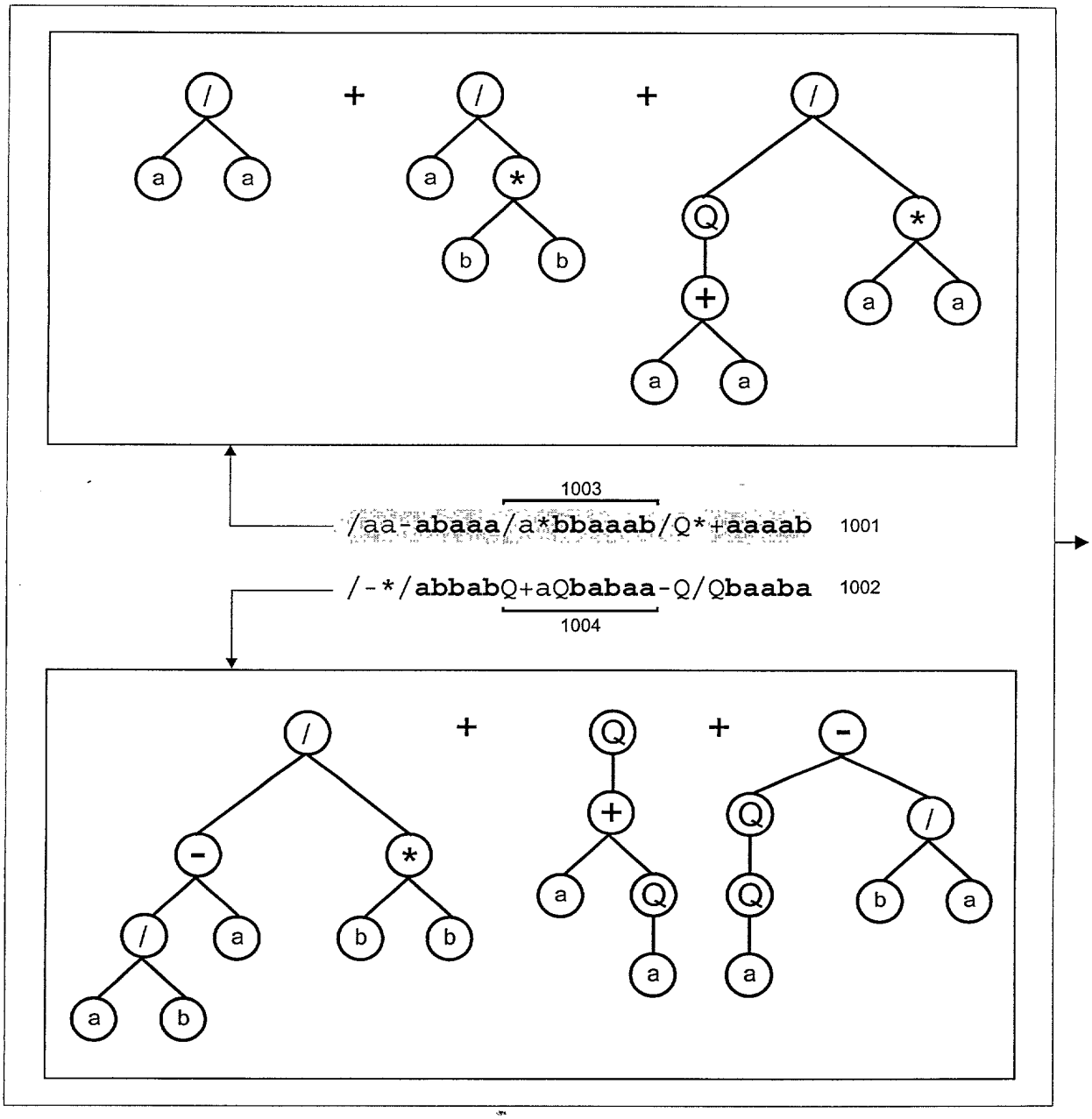

/aa-abaaa/a*bbaaab/Q*+aaaab
1001
1003
/-*/abbabQ+aQbabaa-Q/Qbaaba
1002
1004

FIG 10B

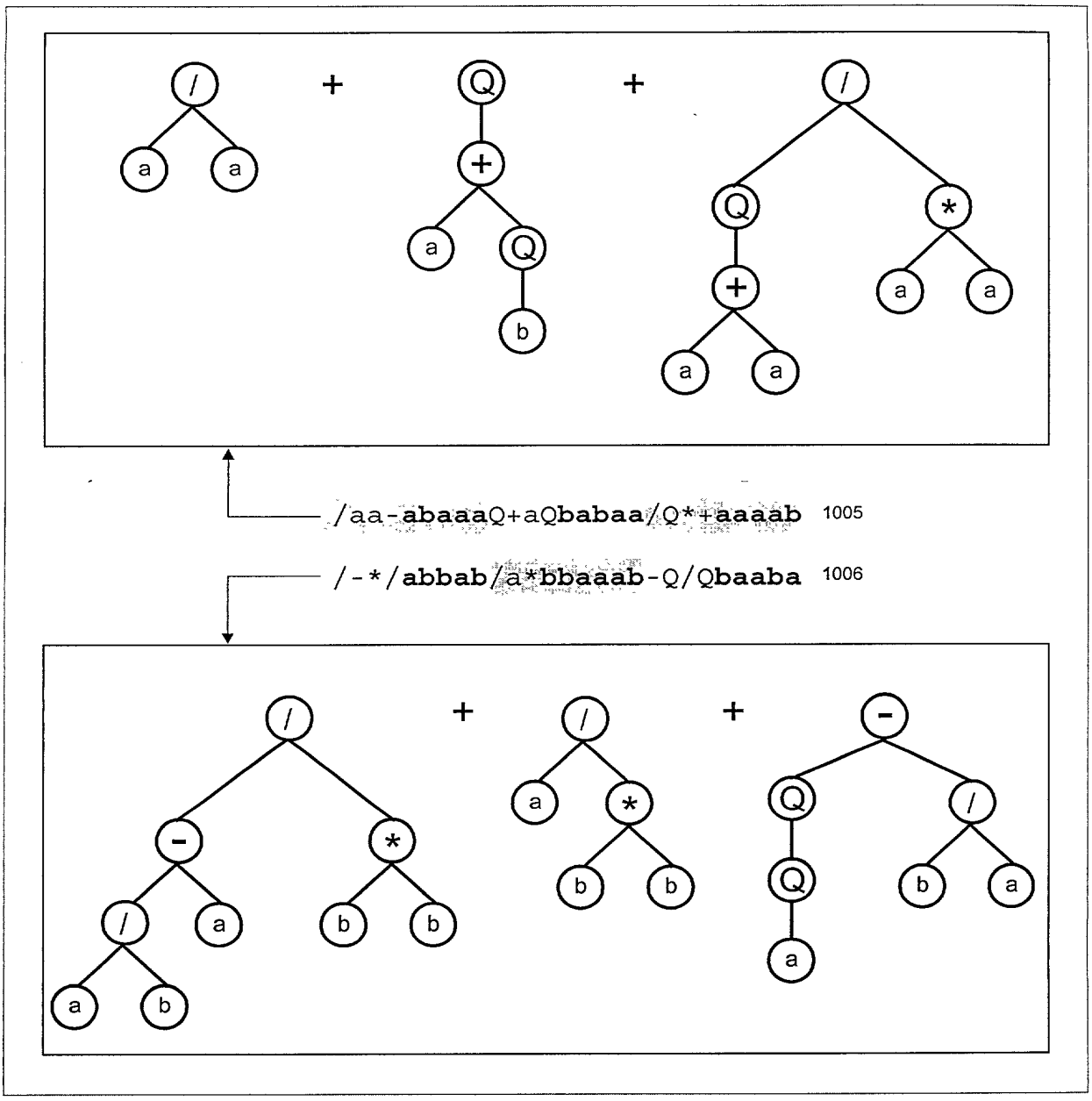


FIG 11

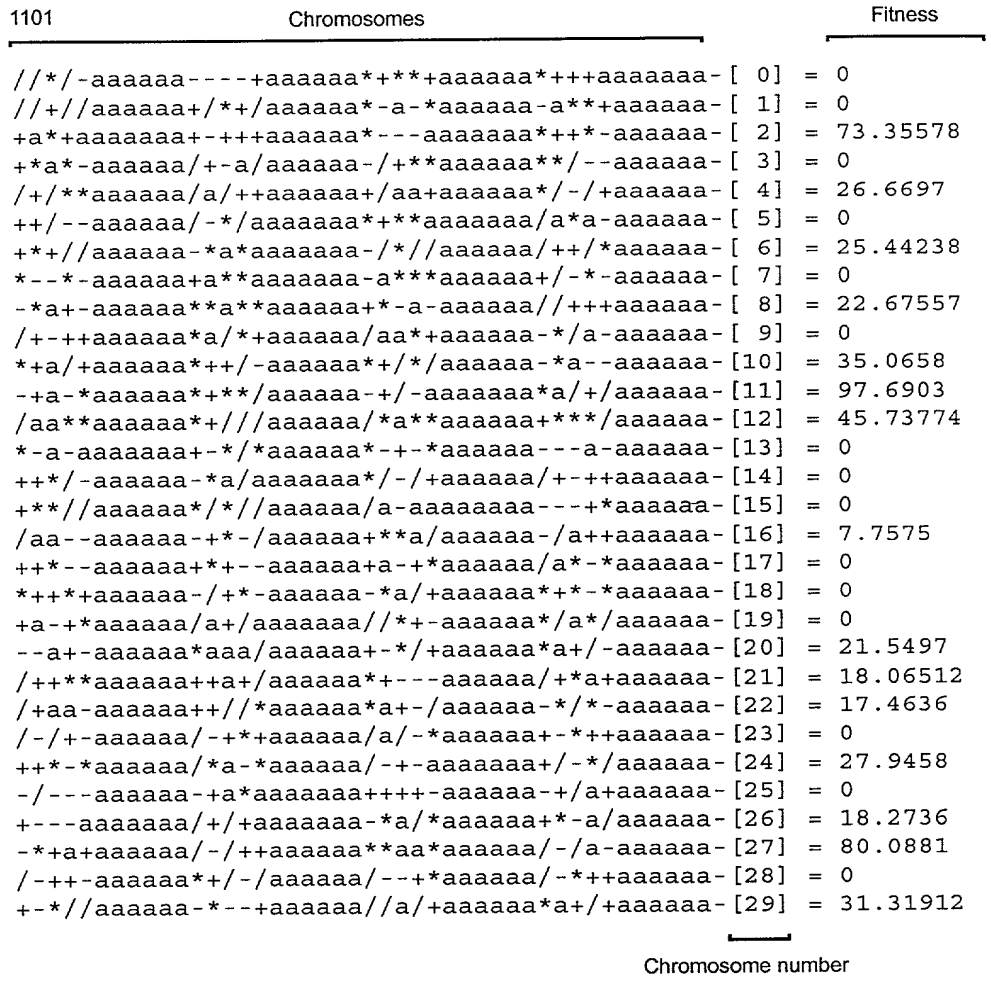


FIG 12

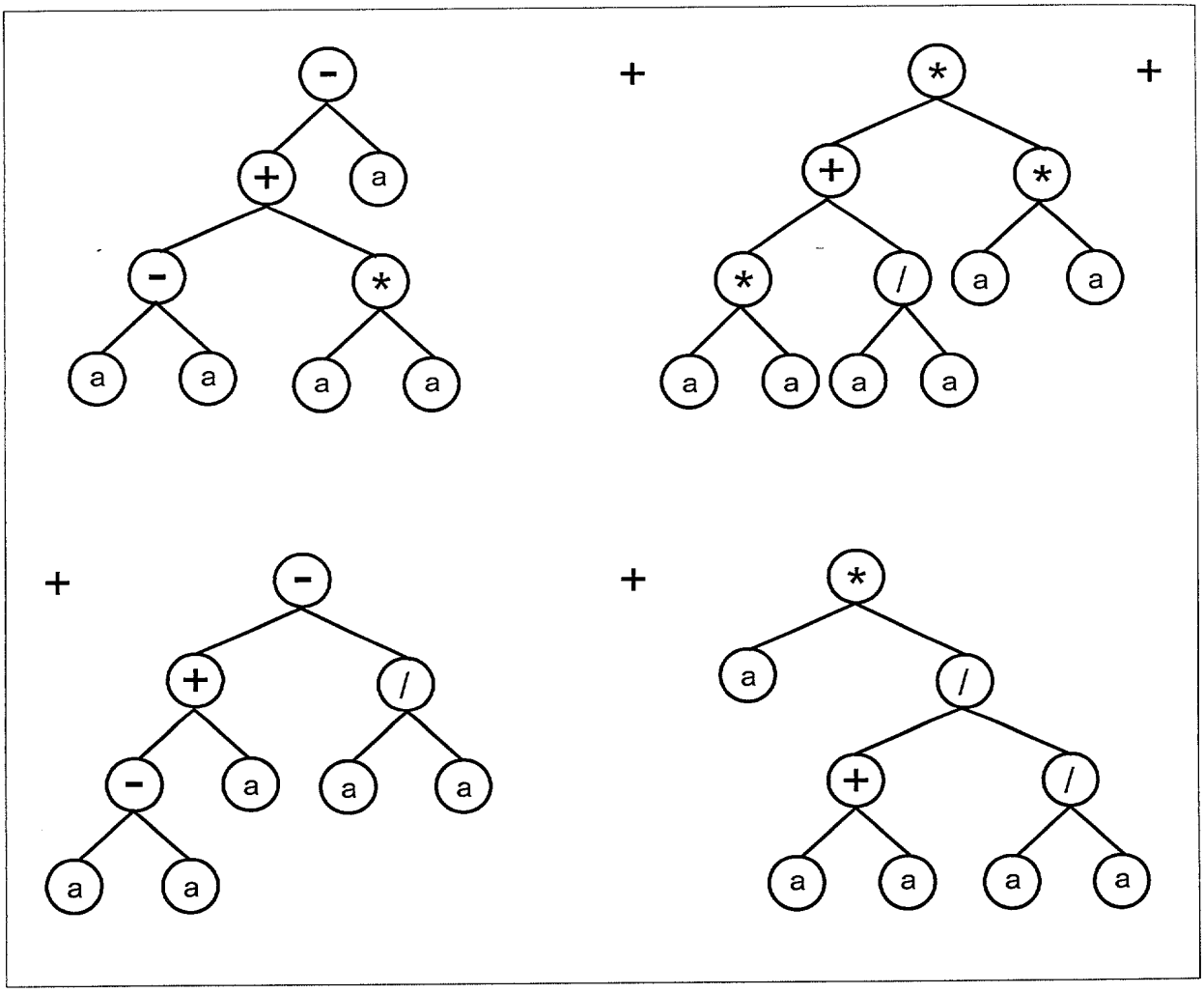
Chromosome

1201

```
-+a-*aaaaaa*+**/aaaaaa-+/-aaaaaaa*a/+/aaaaaa
```

Expression tree

1202



Mathematical expression

1203

$$y = (a^2 - a) + (a^4 + a^2) + (a - 1) + (2a^2) = a^4 + 4a^2 - 1$$

FIG 13

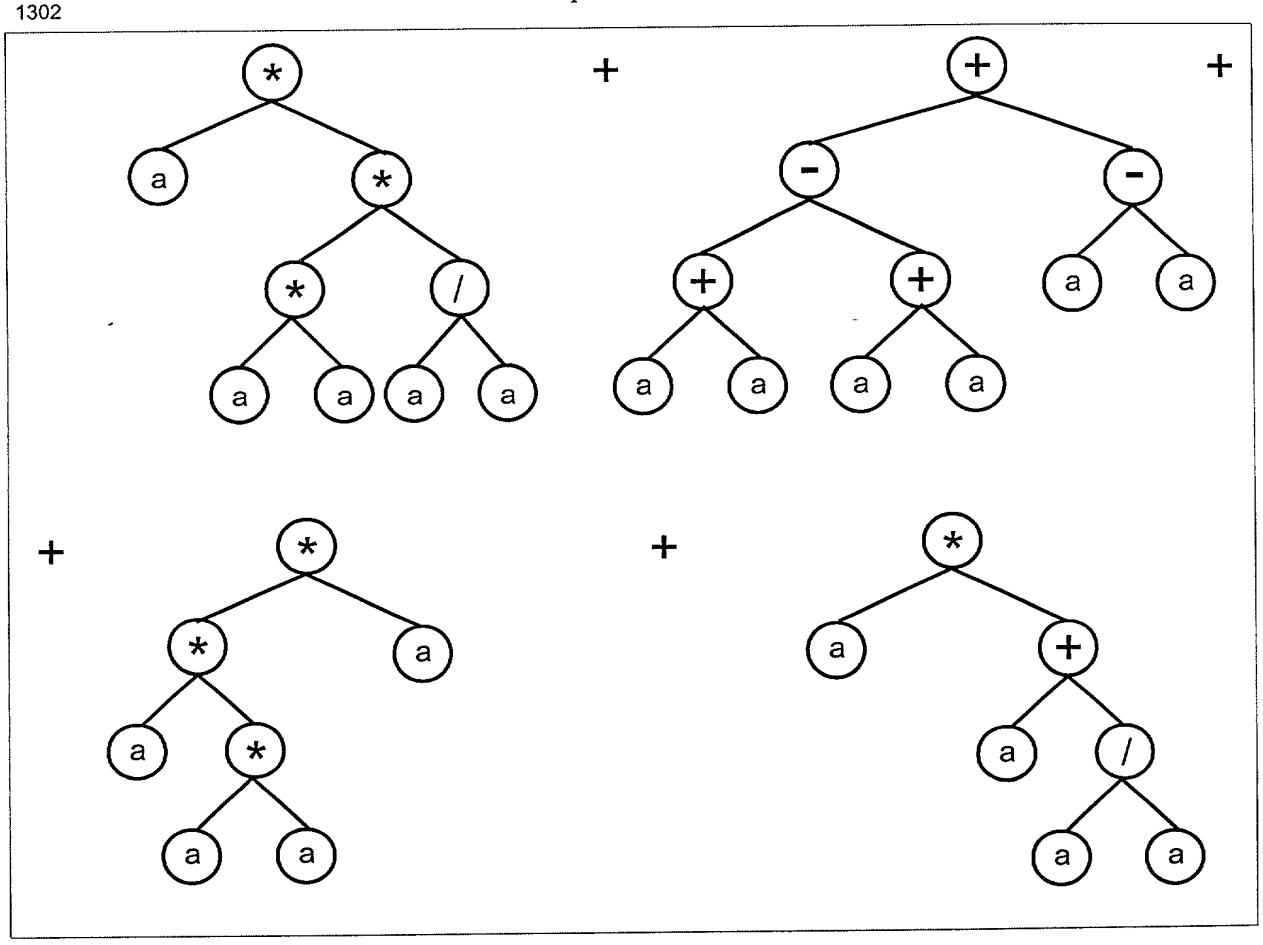
Chromosome

1301

```
*a**/aaaaaa+--++aaaaaa**aa*aaaaaa*a+a/aaaaaa
```

Expression tree

1302



Mathematical expression

1303

$$y = (a^3) + (0) + (a^4) + (a^2 + a) = a^4 + a^3 + a^2 + a$$

FIG 14

	Present Invention	Genetic Programming
G	50	51
P	30	500
C	10	20
P_s	1	0.35
R_z	1	11
F_z	15,000	5,610,000

FIG 15

Fitness cases' stacks

```
luaine###-0
unervsi##-1
auvse####-2
nalvuesri-3
s########-4   1501
sluavn###-5
esiv#####-6
narsv####-7
vlera####-8
#########-9   1502
```

```
1503          Chromosomes                       Fitness

    ApAAtuputCuRuputptAttCtptuu-[ 0]  = 1
    ARRpttutpAAupupuupNCRNutttu-[ 1]  = 0
    CCRApttttCApNuptppRNAAttpup-[ 2]  = 1
    ANpNttuptCARptutuuNRpAtttut-[ 3]  = 1
    ARCRtpptuRuuAppptpAttpuptup-[ 4]  = 1
    ApuApuuutAARCutupuACNptpppu-[ 5]  = 0
    RARuputppCACApttupRRCNttutu-[ 6]  = 0
    AtAuppppuCuAtppptuNACAtttpp-[ 7]  = 1
    NtNAuputpACutppptuCuCRptppu-[ 8]  = 0
    NtANpptutAuRptpppuRpNAutupu-[ 9]  = 1
    AuututttuRptRptttuRAARutupt-[10]  = 0
    CpNRtuuupCCCNpupptRptCuptuu-[11]  = 2
    RACAuptutCACtutuupNRtNptput-[12]  = 1
    AApNuuttpANCuptutuRCAutptup-[13]  = 0
    CtCututtuCAAAutptuANRNuttpt-[14]  = 0
    CAAptputtCAtNutppuAtpAtutut-[15]  = 1
    NpAAuppupAAAuptpuuAttRtputt-[16]  = 1
    AARtttuuuNAARtppuuAutuutptp-[17]  = 1
    ApRAtutptNNAAppppuACtRptuup-[18]  = 0
    AAApppputRNACupptpACNttuptu-[19]  = 0
    CpRNppppuACANttuttNAAAutput-[20]  = 2
    AtNAututtAupttuupARRCtuppp-[21]  = 0
    CAAAtputuAtANptpupAAptpuuut-[22]  = 1
    ARNRtuuupApAtttputApRNupuut-[23]  = 0
    RtNNtpuppCtAuuuppuCAANpuutu-[24]  = 0
    RCAtuupttAutAptutpAAtAtttuu-[25]  = 0
    RtuAuputtAAAptututRpRpptpuu-[26]  = 1
    CpAAtputuCCpNpttutAuuRppupt-[27]  = 2
    AACRtpupuRuAAttuptCAuuppuuu-[28]  = 2
    RuAAputtuRACNuupptAuRppuupp-[29]  = 2

                                Chromosome number
```

FIG 16

Fitness cases' stacks

1601

```
rilasnvu#-0
rls######-1
anruievls-2
nr#######-3
viaslre##-4
ievlanru#-5
uenari###-6
neai#####-7
li#######-8
#########-9
```

1602

1603 Chromosome

uNpNttuptCARpuutup**NRpCtutut**

Expression tree

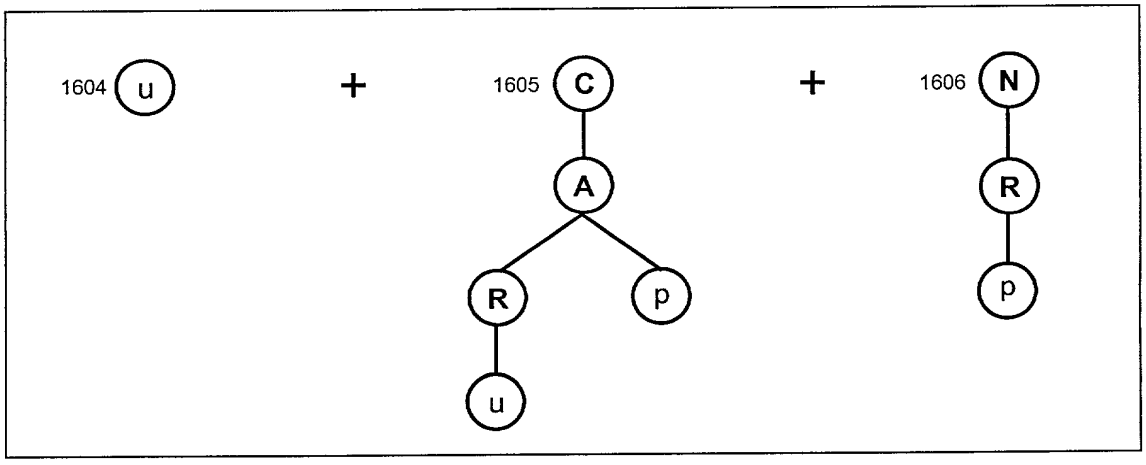


FIG 17

Fitness cases' stacks

```
s########-0
vulnsiaer-1
iuvr#####-2
riev#####-3
ui#######-4
isunrl###-5
uniav####-6
lireav###-7
ni#######-8
#########-9
```

1701 Chromosome

ARpCuututCARpuuuupACtptpuut

Expression tree

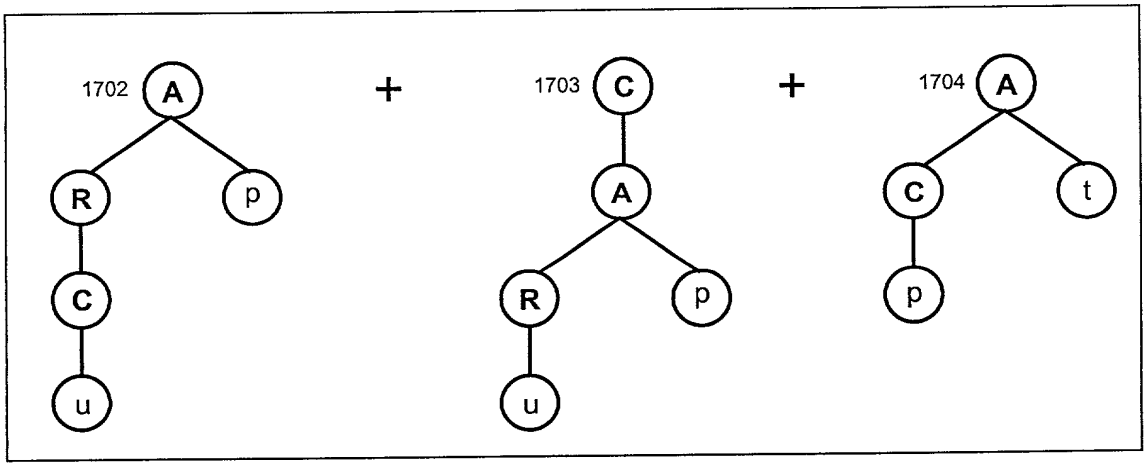


FIG 18

Fitness cases' stacks

```
avnurle##-0
vsrui####-1
uerlvsnai-2
saelnu###-3
linv#####-4
sivnrlaeu-5
vulrsaine-6
esla#####-7
vnarlsei#-8
#########-9
```

1801 Chromosome

CutputuptARpuuuttpACNRppuuu

Expression tree

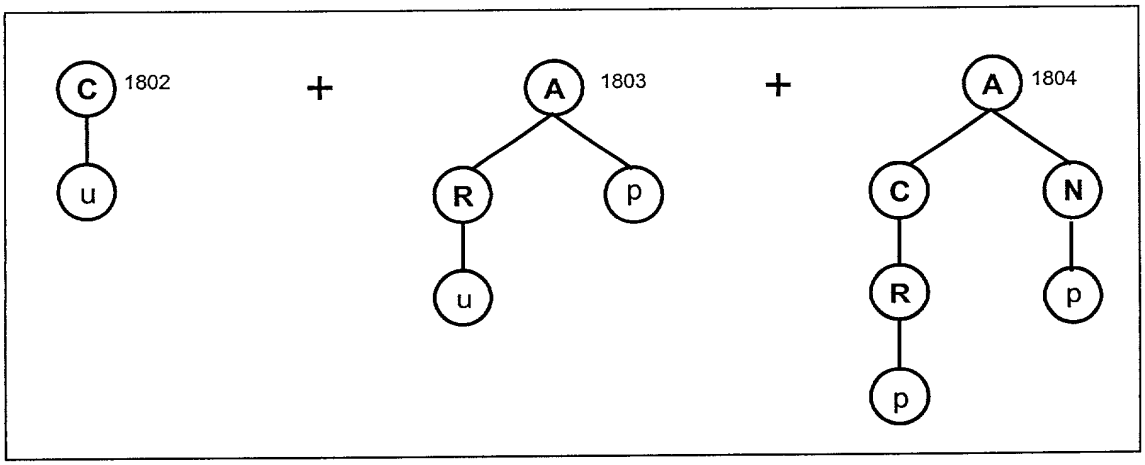


FIG 19

	Present Invention	Genetic Programming
G	100	51
P	30	500
C	10	167
P_s	0.70	0.767
R_z	4	4
F_z	120,000	17,034,000

FIG 20

2001 Chromosome Fitness

AO31N4322a4AAAbb342444**AAAaN244bb3**AAA2Nbb3a1b = 44

2002 Expression tree

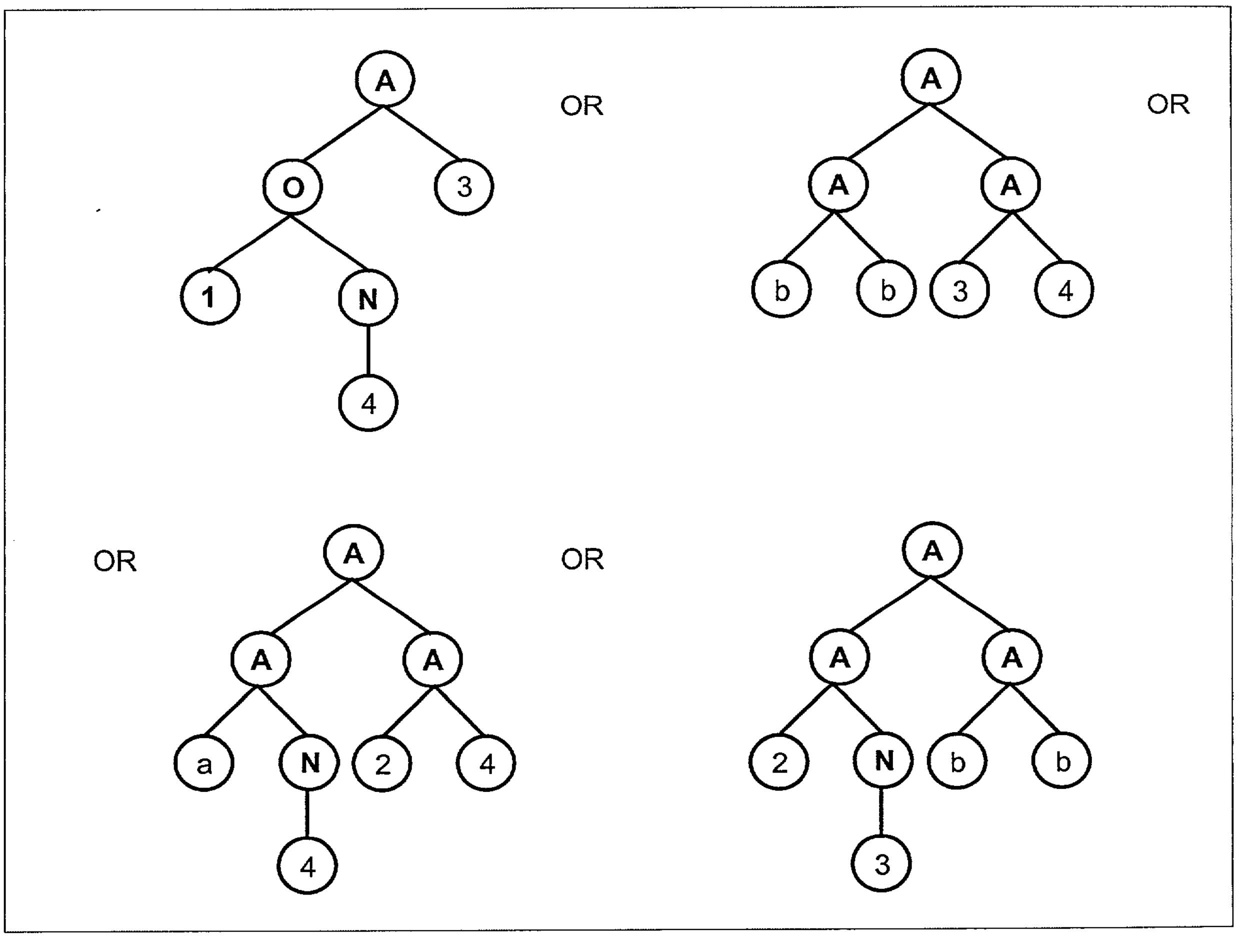


FIG 21

2101 Chromosome Fitness

A1A2Ob4443a AaO3O133311**AaO3bbbb322**AO21Abb4a33 = 132

2102 Expression tree

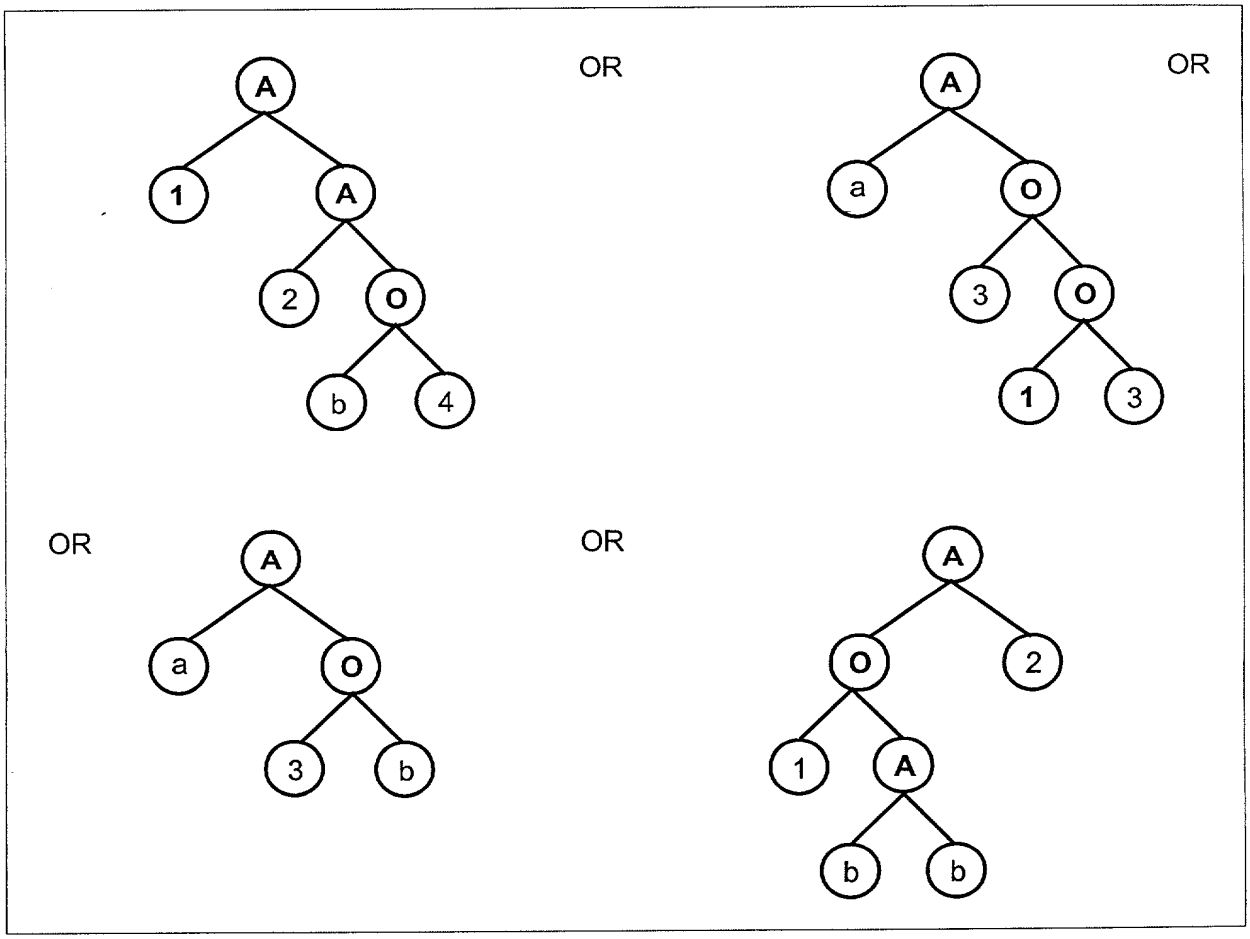


FIG 22

2201 Chromosome Fitness

AOOOAa21b3a AaO33133311**AaN31bb4321**AON1Abb4a3b = 216

2202 Expression tree

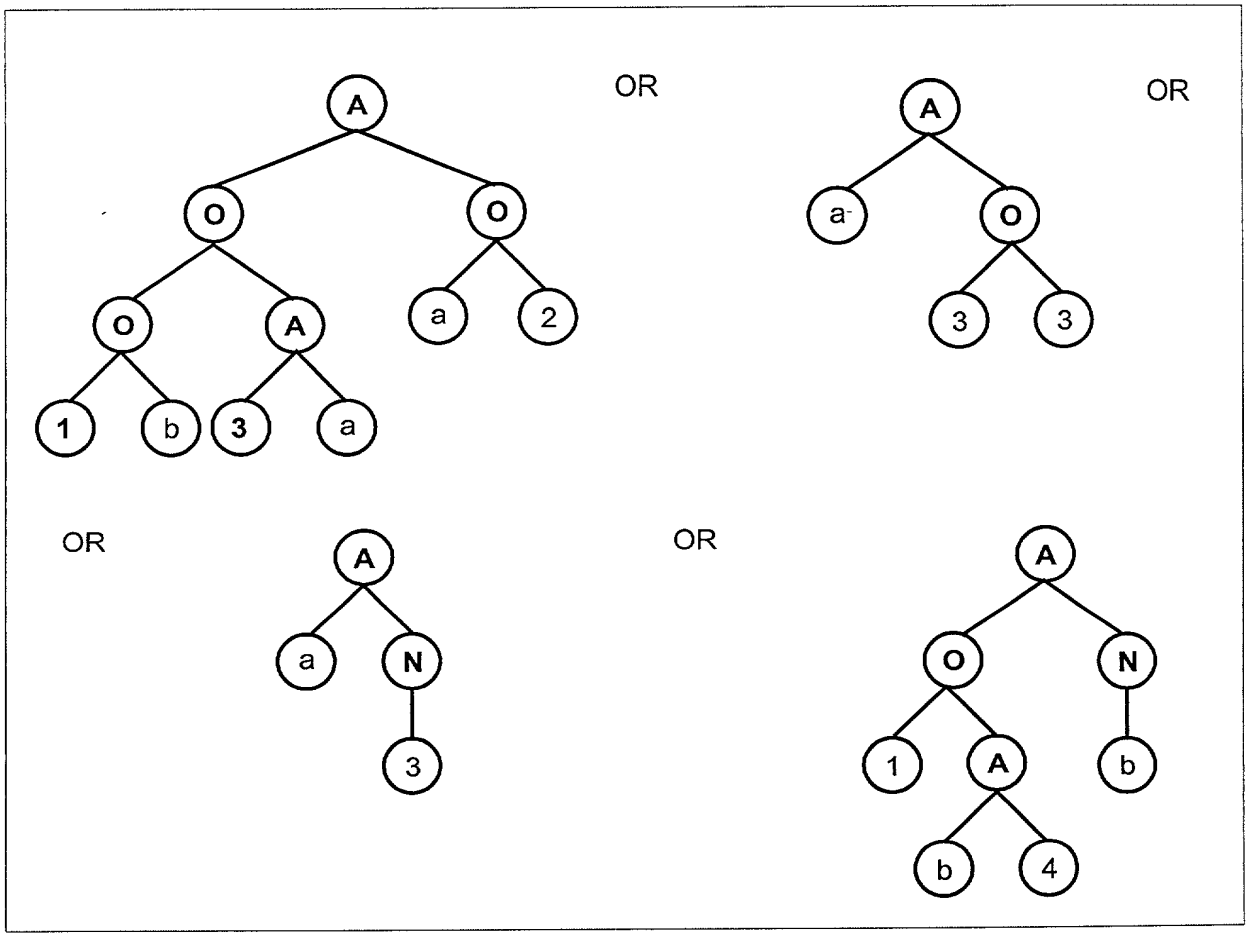


FIG 23

2301 Chromosome Fitness

AAN2baa4b2bAAO4Ab33a31**AaANA3b4312**AON1bb1b233 = 310

2302 Expression tree

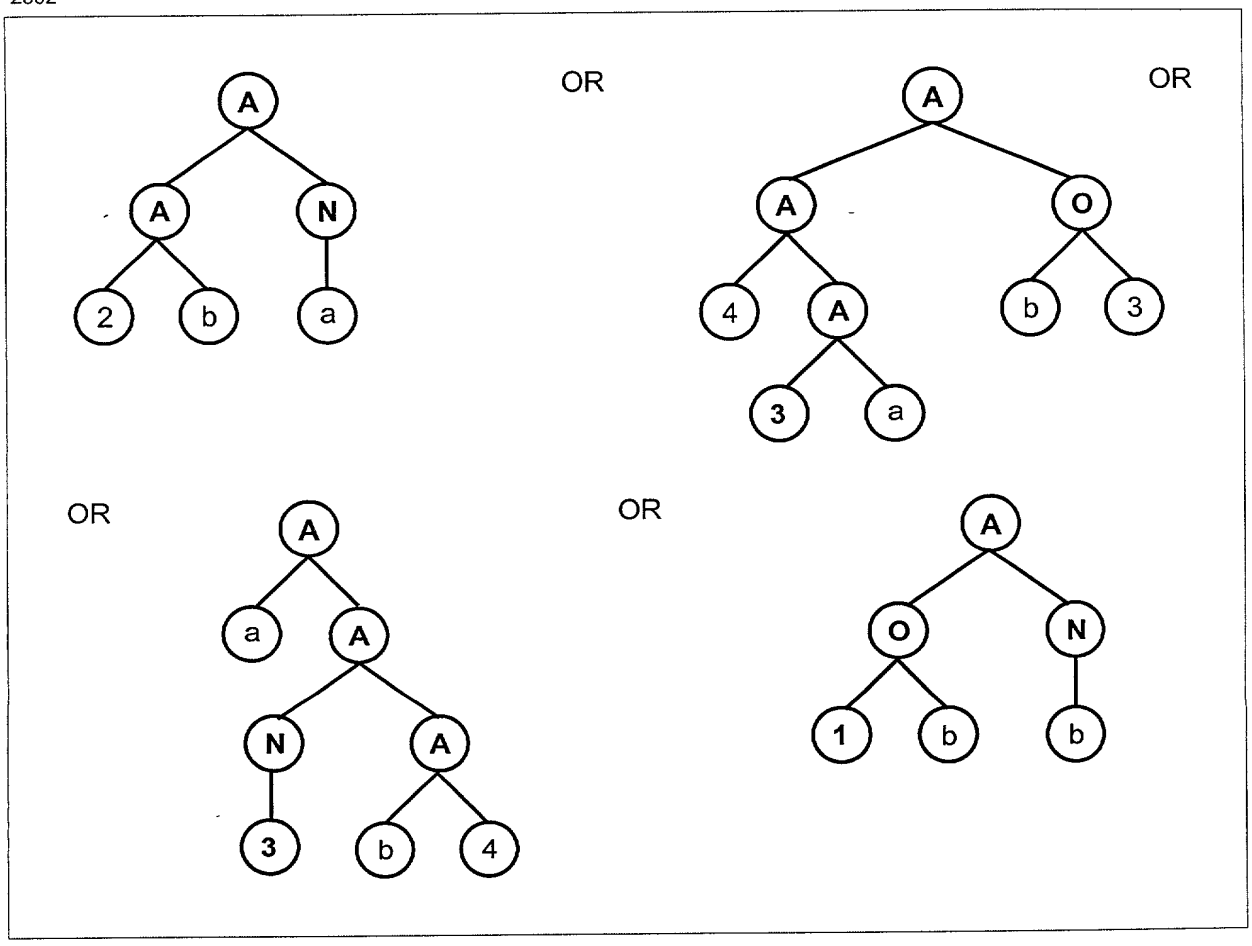


FIG 24

2401 Chromosome Fitness

AANAba22a41AAObAb14a2b**AaA3Nba1111**AAN1Nba2a2b = 400

2402 Expression tree